(18) AEC

(8)

(6) ~~REPORT TO THE TEST DIRECTOR~~

AIR SHOCK PRESSURE-TIME VS DISTANCE

(Project 19.1a)

(9) Rept. for Apr - Jun 52,

~~by~~

(10) B. F. MURPHEY DIVISION 5111

(11) ~~date~~

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Date: 7 March 1968

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ATOMIC ENERGY ACT 1954

SANDIA CORPORATION
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Table 1.3 -- RESULTS OF TUMBLER SHOT 1 (APRIL 1, 1952)
Radiochemical yield (as of June 10, 1952): 1.06 kt
Location of burst point: 67 ft E, 122 ft N from intended ground zero
Height of burst: 793 ft

Station	Distance[a] (ft)	Slant range[a] (ft)	Peak positive pressure (psi)	Duration of positive phase (msec)	Positive impulse (psi-sec)	Maximum negative pressure (psi)	Duration of negative phase (msec)	Negative impulse (psi-sec)
0-0-P	177	813						
1-0-P	357	869	19.4	215	1.6	-3.0	920	-1.65
2-2-P	590	986.8	15.6	239	1.42	-2.2	900	-1.25
2-6-P		983.4	15	242	1.36	-2.3	890	-1.29
2-20-P		972.4	8.3[b]	252	0.8[b]	-1.3	840[b]	-0.7[b]
2-35-P		960.5	11.8	262	1.2	-1.85	857	-1.05
3-0-P	833	1,150	11.1	257	1.10	-1.9	866	-0.91
5-0-P1	1,328	1,546	9.7	274	0.80	-1.5	990	-0.90
5-0-P2			9.7	286	0.80	-1.3	985	-0.78
6-2-P	1,577	1,765	7.2	303	0.67	-1.1	944	-0.61
6-6-P			7.8	296	0.68	-1.25	951	-0.676
6-20-P			7.3	290	0.69	-1.3	960	-0.74
6-35-P			6.3	309	0.71	-1.2	935	-0.65
7-0-P	1,825	1,990	6.42	330	0.65	-0.92	940	-0.52
9-0-P	2,573	2,692	3.4	341	0.43	-0.70	1,100	-0.43
11-0-P	4,069	4,147	1.72	406	0.257	-0.36	1,030	-0.221

[a]These distances are actual distances, computed from the observed location of the burst point, which was d
mined to within ±20 feet.

[b]Obviously in error.

NOTE: In nearly every instance a small positive pressure of 0.2-0.5 psi follows the end of the negative pha
1/4 second.

Table 1.4 -- RESULTS OF TUMBLER SHOT 2 (APRIL 15, 1952)
Radiochemical yield (as of June 10, 1952): 1.19 kt
Location of burst point: 84 ft E, 143 ft S from intended ground zero
Height of burst: 1,100 ft

Station	Distance[a] (ft)	Slant range[a] (ft)	Peak positive pressure (psi)	Duration of positive phase (msec)	Positive impulse (psi-sec)	Maximum negative pressure (psi)	Duration of negative phase (msec)	Negative impulse (psi-sec)	Tim arr (s
1-0-P	633	1,277	10.4	263	1.02	-1.94	1,320	-1.00	0.
2-2-P	1,378	1,769	5.8	305	0.71	-1.3	909	-0.69	1.
2-6-P			6.4	296	0.70	-1.3	1,030	-0.72	1.
2-20-P			5.8	312	0.71	-1.2	1,165	-0.65	1.
2-35-P			5.0	313	0.61	-1.2	1,394	-0.65	1.
3-0-P	2,126	2,398	5.1	324	0.50	-0.92	1,600	-0.52	1.
5-0-P1	3,625	3,791	2.6	366	0.32	-0.57	972	-0.32	2.
5-0-P2			2.5	412	0.35	-0.42	1,090		2.
6-2-P	4,375	4,514	1.98	408	0.26	-0.39	972	-0.23	3.
6-6-P			1.83	401	0.26	-0.45	1,027	-0.25	3.
6-20-P			1.83	430	0.25	-0.34	972	-0.19	3.
6-35-P			2.01	419	0.28	-0.34	932		3.
7-0-P	5,125	5,244	1.30	442	0.21	-0.31	914	-0.17	4.
9-0-P	7,375	7,458	1.02	441	0.17	-0.28	1,065	-0.16	5.
11-0-P	11,673	11,723	0.45	500	0.072	-0.13	1,213	-0.078	9.

[a]These distances are actual distances, computed from the observed location of the burst point, which was det mined to within ±20 feet.

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Table 1.5 -- RESULTS OF TUMBLER SHOT 3 (APRIL 22, 1952)
Radiochemical yield (as of June 10, 1952): 30 kt
Location of burst point: [illegible]0 ft S, 124 ft W from intended ground zero
Height of burst: 3,447 ft

Station	Distance[a] (ft)	Slant range[a] (ft)	Peak positive pressure (psi)	Duration of positive phase (msec)	Positive impulse (psi-sec)	Maximum negative pressure (psi)	Duration of negative phase (msec)	Negative impulse (psi-sec)	Time … arriv… (sec)
1-0-P	659	3,509	11.0	751	3.12	-2.0	3,100	-3.6	1.74
2-2-P	1,404	3,722	9.6	809	2.81	-1.6	2,900	-2.67	1.91
2-6-P			10.3	811	3.02	-1.8	3,000	-3.00	1.91
2-20-P			8.5	840	2.62	-1.3	3,200	-2.31	1.90
2-35-P			10.3	820	3.10	-1.8	3,500	-3.22	1.89
3-0-P	2,153	4,064	9.6	900	3.26	-1.5	2,400	-2.18	2.18
5-0-P1	3,652	5,022	6.6	880	2.17	-1.28	3,200	-2.38	2.96
5-0-P2			6.25	936	2.05	-0.85	3,300	-1.65	2.96
6-2-P	4,401	5,591	5.7	909	1.83	-1.0	3,300	-1.82	3.43
6-6-P			5.7	916	1.88	-1.1	3,500	-2.01	3.43
6-20-P			6.4	940	2.05	-1.1	3,300	-2.09	3.42
6-35-P			6.4	882	1.97	-1.2	3,200	-2.02	3.41
7-0-P	5,151	6,[illegible]	6.1	960	1.93	-0.95	3,400	-1.70	3.93
9-0-P	7,401	8,164	4.2	1,000	1.22	-0.70	3,300	-1.33	5.59
11-0-P		12,198	2.1	1,200	0.69	-0.70			9.03

[a]These distances are actual distances, computed from the observed location of the burst point, which was determined to within ±20 feet.

Table 1.6 -- RESULTS OF TUMBLER SHOT 4 (MAY 1, 1952)
Radiochemical yield (as of June 10, 1952): 19.6 kt
Location of burst point: 153 ft W, 140 ft S from intended ground zero
Height of burst: 1,040 ft

Station	Distance[a] (ft)	Slant range[a] (ft)	Peak positive pressure (psi)	Duration of positive phase (msec)	Positive impulse (psi-sec)	Maximum negative pressure (psi)	Duration of negative phase (msec)	Negative impulse (psi-sec)	Time [illegible] arri[illegible] (se[illegible]
1-0-P	599	1,200	72	330	7.0	-6	1,040	-4.1	0.2[illegible]
2-2-P	1,341	1,697	38						0.4[illegible]
2-6-P			35						0.4[illegible]
2-20-P			22						0.4[illegible]
2-35-P			25						0.4[illegible]
3-0-P	2,090	2,333	9.2	700	3.18	-2.2	3,200	-3.24	0.8[illegible]
5-0-P1	3,587	3,735	6.2	817	1.98	-1.6	3,400	-1.95	1.9[illegible]
5-0-P2			5.6	863	1.80	-1.0	3,450	-1.14	1.9[illegible]
6-2-P	4,337	4,459	4.35	900	1.52	-1.0	3,600	-1.24	2.5[illegible]
6-6-P			4.5	900	1.62	-1.1	3,400	-1.31	2.5[illegible]
6-20-P			4.95	930	1.72	-1.04	3,250	-1.36	2.5[illegible]
6-35-P			4.95	920	1.57	-1.0	3,000	-1.21	2.5[illegible]
7-0-P	5,087	5,192	3.6	970	1.40	-0.98	3,400	-1.27	3.1[illegible]
9-0-P	7,337	7,407	2.15	1,040	0.94	-0.8	3,800	-1.13	4.9[illegible]
11-0-P	11,637	11,682	1.10	1,370	0.70	-0.35	3,200	-0.47	8.5[illegible]

[a] These distances are actual distances, computed from the observed location of the burst point, which was dete[illegible] mined to within ±20 feet.

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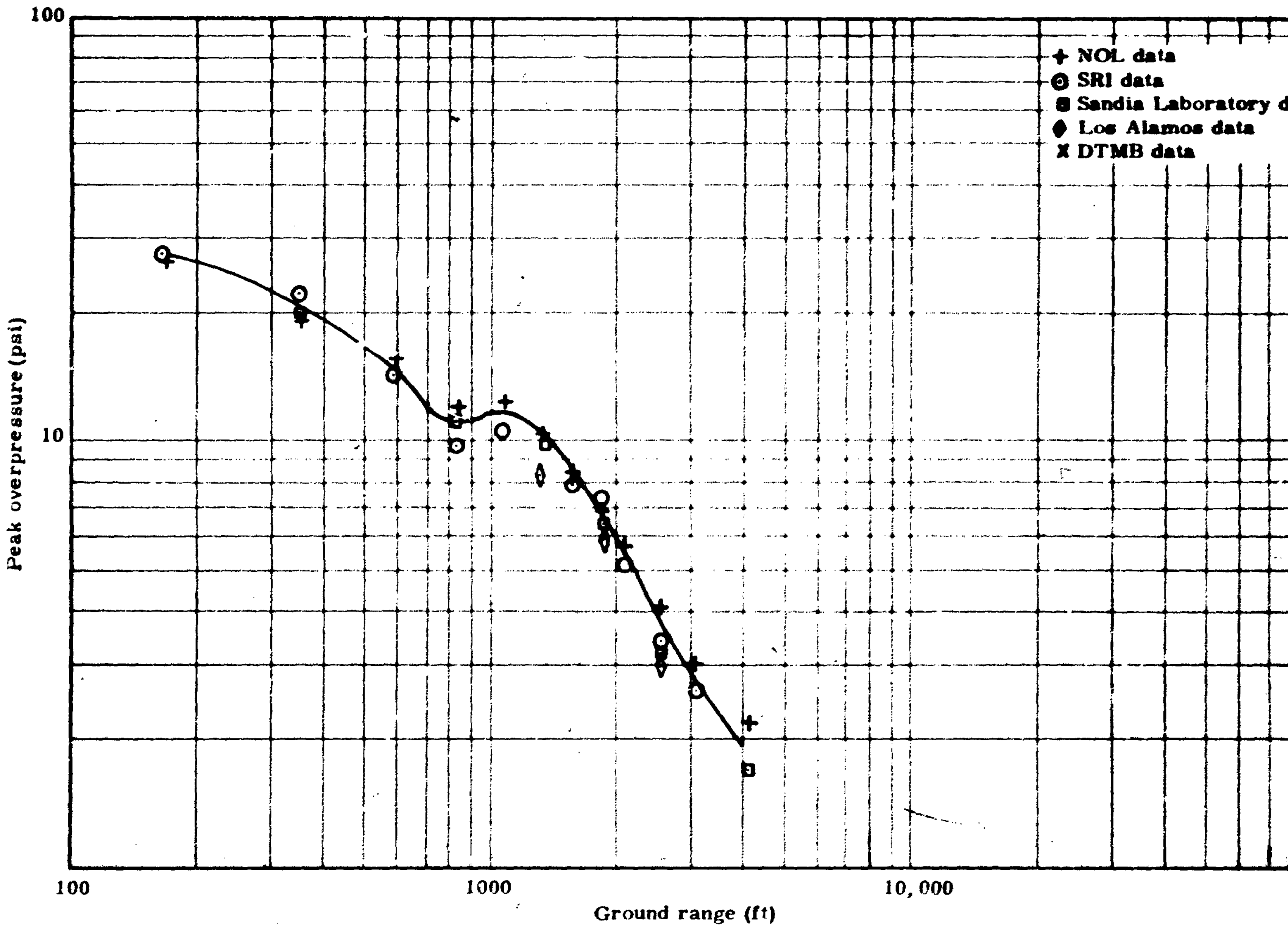

Fig. 1.5 -- Composite pressure-distance curve for Tumbler Shot 1 presenting data from all participating organizations

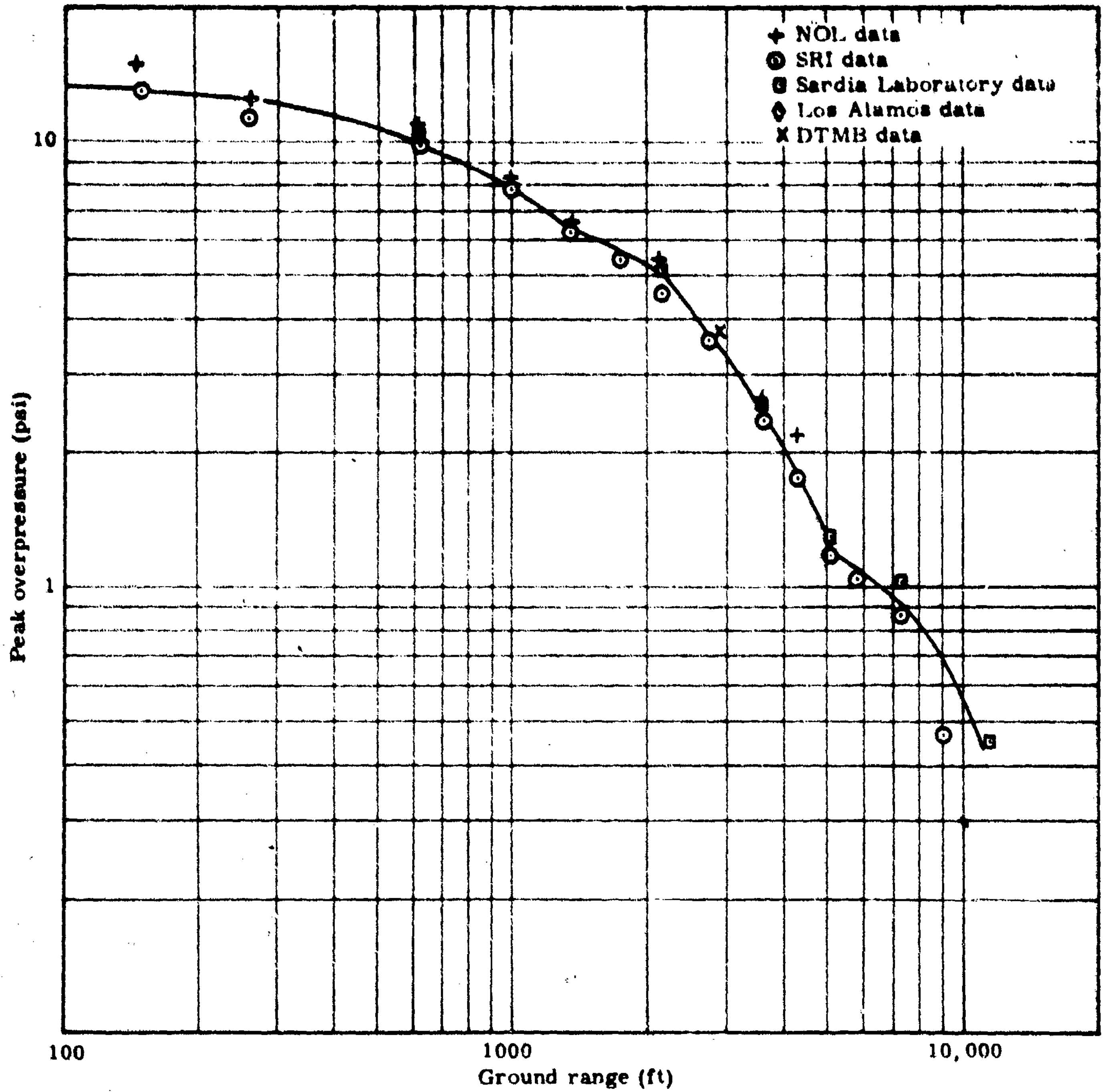

Fig. 1.6 -- Composite pressure-distance curve for Tumbler Shot 2 presenting data from all participating organizations

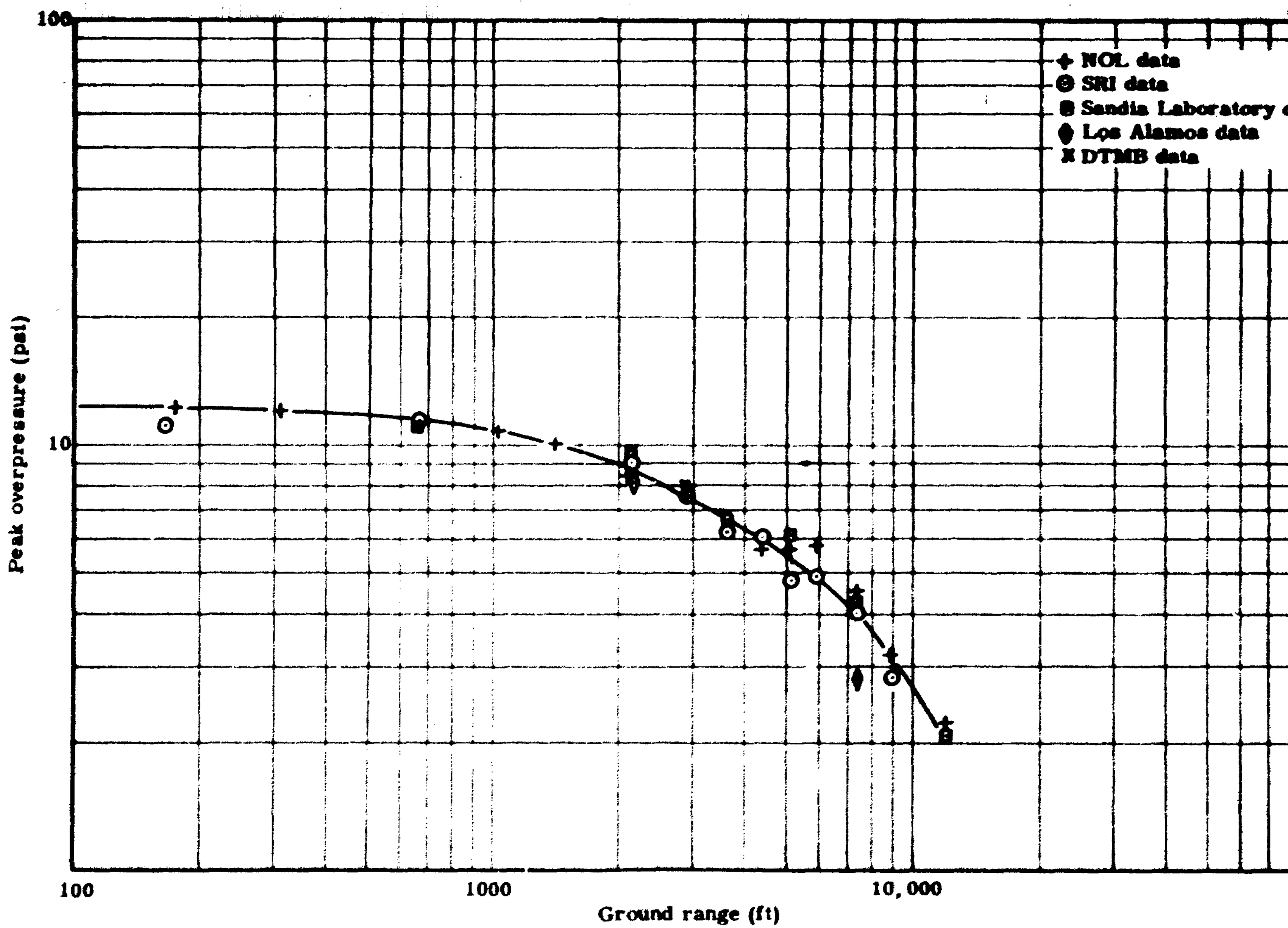

Fig. 1.7 -- Composite pressure-distance curve for Tumbler Shot 3 presenting data from all participating organizations

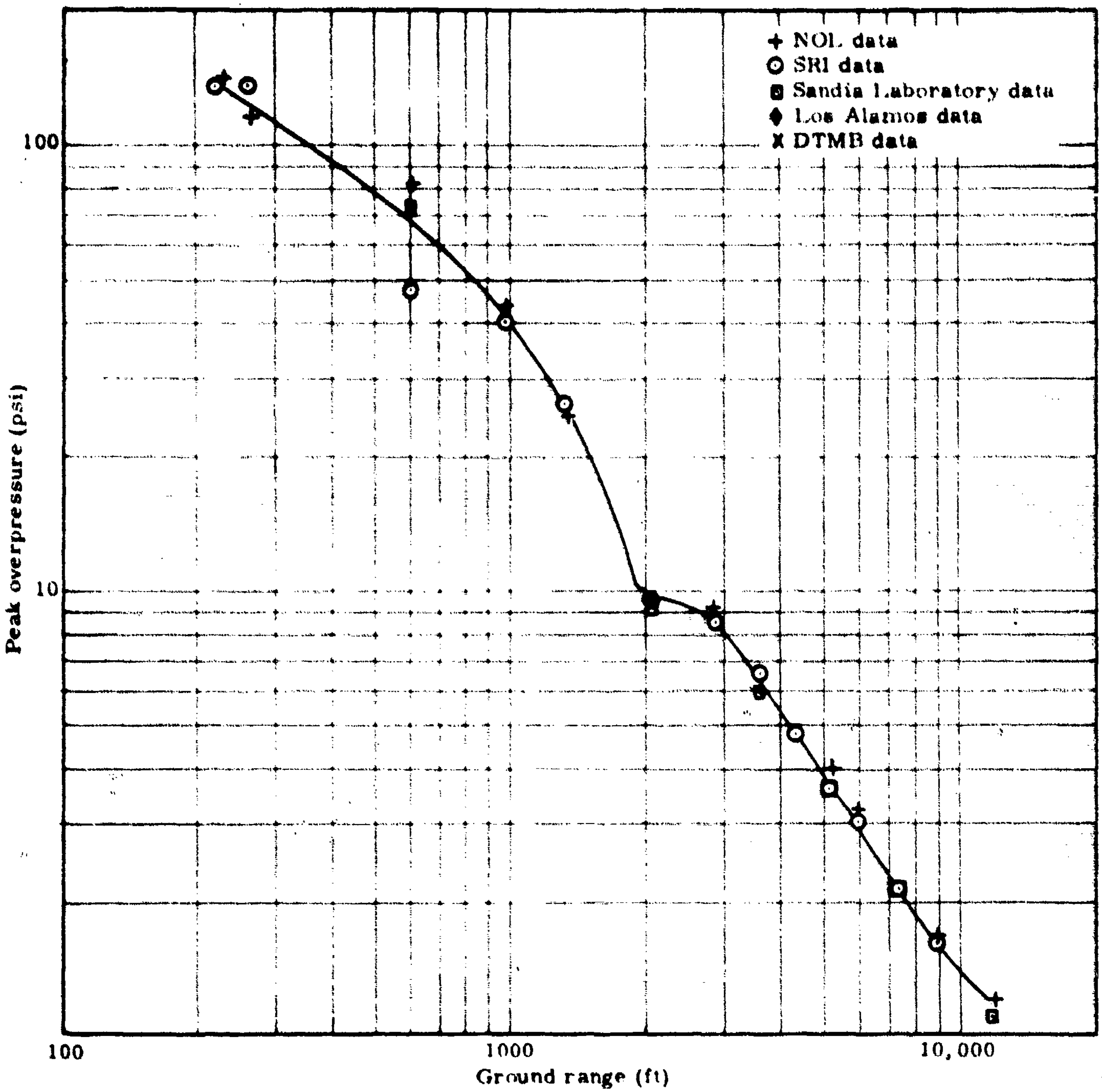

Fig. 1.8 -- Composite pressure-distance curve for Tumbler Shot 4 presenting data from all participating organizations

stations as close as in Station 202.

This precursor, a forerunner of the main pressure rise associated with the primary pressure wave, has a slower rise time and smaller amplitude than the main shock wave and is absorbed into the main shock front at a distance of approximately 2000 feet from ground zero. Formation of a precursor was also observed on Buster Shot Charlie; pressure-time records indicated that it formed at some point beyond 400 feet* from ground zero and was absorbed into the main shock wave in the vicinity of 2000 feet from ground zero. Re-examination of photographs of Buster Shot Charlie seems to corroborate the evidence of the pressure-time records; photographs also seem to show formation of a precursor wave on Buster Shot Dog and do show the dust pedestal associated with the presumed precursor on Shot Easy.

A suggested mechanism for the formation of the precursor is the absorption of thermal energy by the ground and release of water of crystallization by the constituents of the earth's crust, causing a sudden evolution of a relatively large amount of heated material.† The presence of this heated material throughout the region above ground level is presumed to affect substantially the progress of the shock wave through it; it becomes a region of velocity dispersion. Since the postulated temperatures are high, this effect is a strong one, and a forerunner is clearly possible.

Ordinarily (except in the region where the Mach stem exceeds 50 feet) at stations where pressure measurements are made at levels above ground level, increases are observed first at the highest level and last at the level nearest the ground. On Tumbler Shot 4, however, arrival of the precursor at the various levels causes the order of arrival to be reversed; for instance data on time of arrival at Station 202 (Table 1.6) indicate that the precursor arrives at the 35-ft level 17 milliseconds after it arrives at the 2-ft level. This 'toeing out' of the

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*Results obtained by the Stanford Research Institute on Tumbler Shot 4 from gauges OB (ground range 233 feet) and 2B (ground range 260 feet) were similar to those from Buster Shot Charlie in that the precursor is not evident at the stations close to ground zero; these results are presented in Preliminary Report - Operation Tumbler Project 1.2 - Air Pressure vs Time, Stanford Research Institute report SU-Q-12, May 9, 1952, by E. B. Doll.

†Bates, J. J., et al, The Thermal and Optical Characteristics of Nevada Sand, Material Laboratory, New York Naval Shipyard, report No. ND-Q-63, May 12, 1952; see also Bleakney W., Interaction of a Shock Wave with a Thermal Boundary Layer, Princeton University Shock Wave Laboratory memorandum report, January 11, 1952; Porzel, F. B., Height of Burst for Atomic Bombs, Los Alamos Scientific Laboratory preliminary report LA-1406 (to be published).

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There are still no experimental data for scaled heights of burst greater than 1000 feet. As can be seen from the chart, these data are needed to establish the burst heights which will give areas of maximum radius for overpressures of 4-8 psi. In particular, a burst at a scaled height of 1,250 feet would provide valuable supplementary information on the shapes of the isobars for 4-8 and perhaps 10-12 psi.

Tumbler Shots 2 (1.19 kt) and 3 (30 kt) produced strong evidence regarding pressures at scaled heights of approximately 1000 feet since measured pressures for these two shots were essentially the same at equal scaled distances. This agreement leads one to conclude that it is valid to scale pressure-distance curves over the range of 1 to 30 kt for bursts at a 1000-ft scaled height.

On the other hand, although the scaled height of burst for Tumbler Shot 1 (1.06 kt) was selected to be the same as that for Buster Shot Baker (3.4 kt), pressures for Buster Baker were considerably lower than for Tumbler Shot 1 at equal scaled distances from ground zero. Similarly, although pressures measured for bursts at a 400-ft scaled height (Tumbler Shot 4 and Buster Shots Charlie and Easy, 14-31 kt) are somewhat scattered, they lie well below those anticipated prior to Operation Buster. It is currently conjectured that these discrepancies in measured pressures are at least partially caused by the thermal effects associated with the formation of the precursor found on shots of large yield at low elevations.

On all shots of the Buster and Tumbler series at scaled heights greater than 600 feet the thermal energy has been less than 90 cal/cm^2 at ground zero, compared with a thermal energy in excess of 300 cal/cm^2 for shots at scaled heights in the vicinity of 400 feet. The thermal energy at ground zero was quite small for Tumbler Shot 1 and Buster Shot Baker, being approximately 55 cal/cm^2 for Tumbler Shot 1 and presumably 70 cal/cm^2 on Buster Baker. The superficial ground surfaces over which these particular shots were burst were quite different: Tumbler Shot 1 was over an almost white surface that was relatively less dusty than that for Buster Baker, which was very dusty and of darker color. Whether the difference in dust and reflectivity would, per se, account for the marked differences in pressure is extremely questionable. Pressure-time records from Buster Baker and Tumbler Shot 1 are similar in that both are almost 'ideal' shock waves and neither shows any evidence of a precursor such as that observed on Tumbler Shot 4 and Buster Shots Charlie and Easy. Discrepancies between the pressures measured on these two series of shots are therefore as yet unexplained.

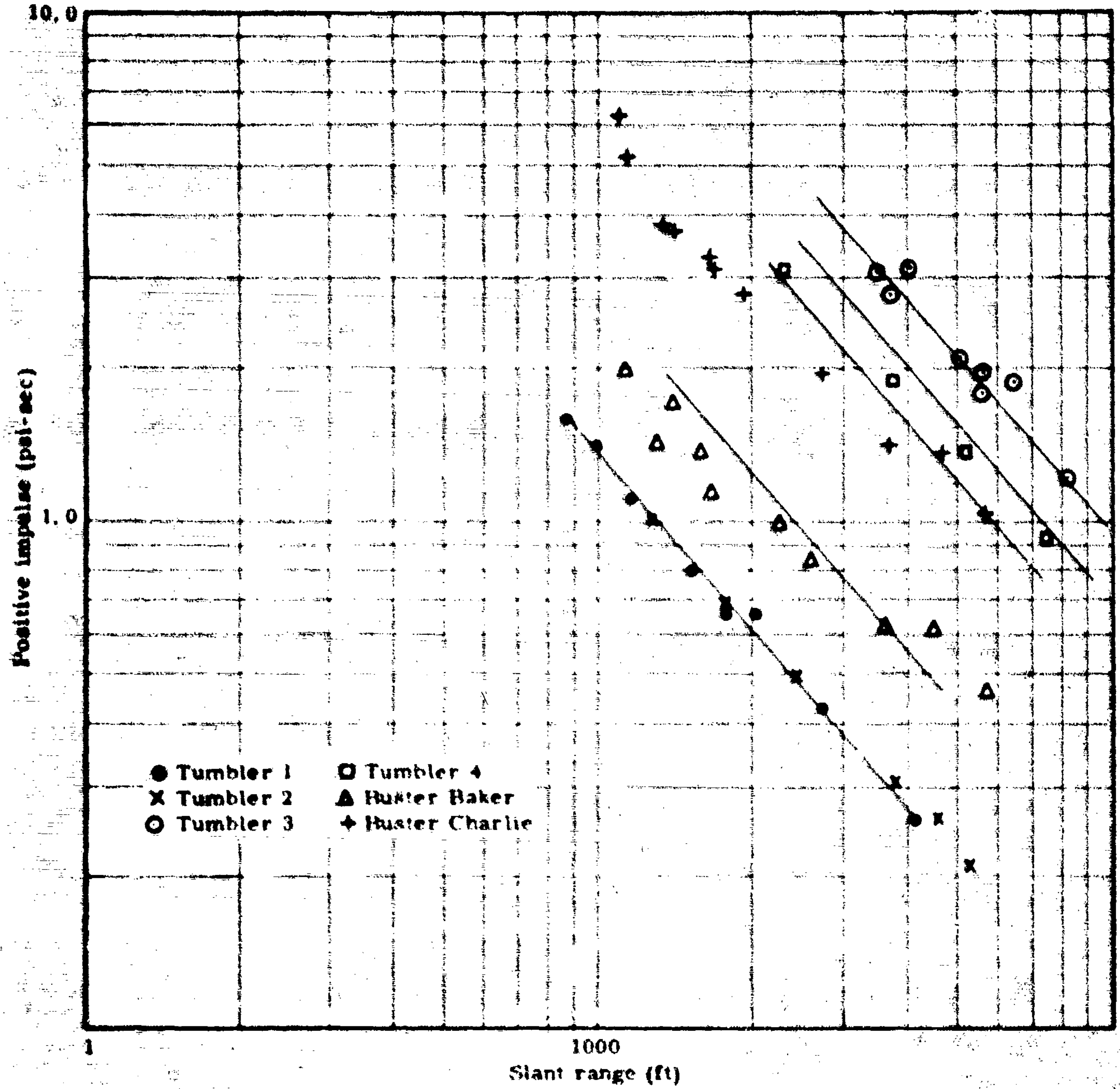

Fig. 1.24 -- Positive impulse vs slant range

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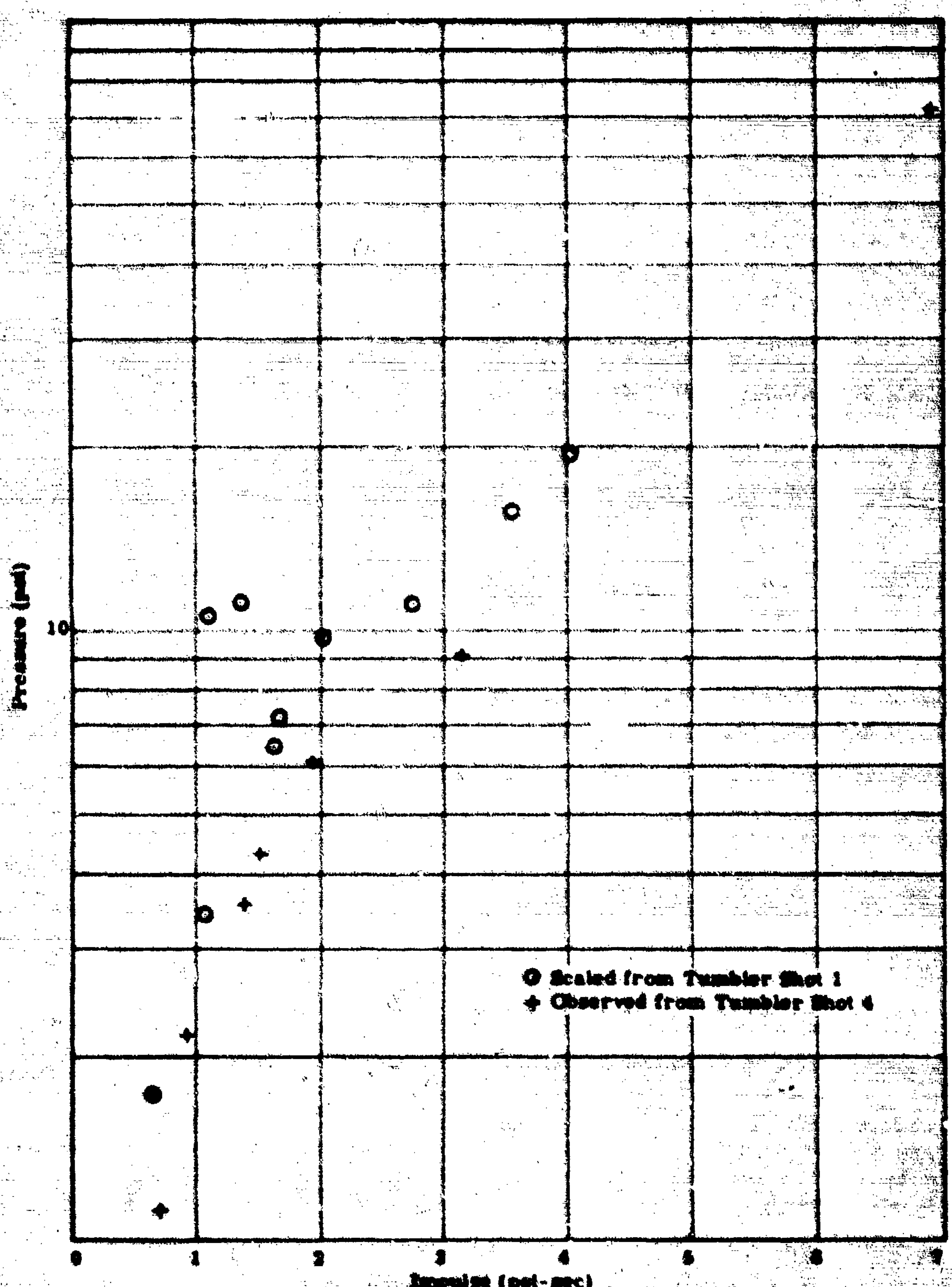

Fig. 1.25 -- Overpressure vs impulse

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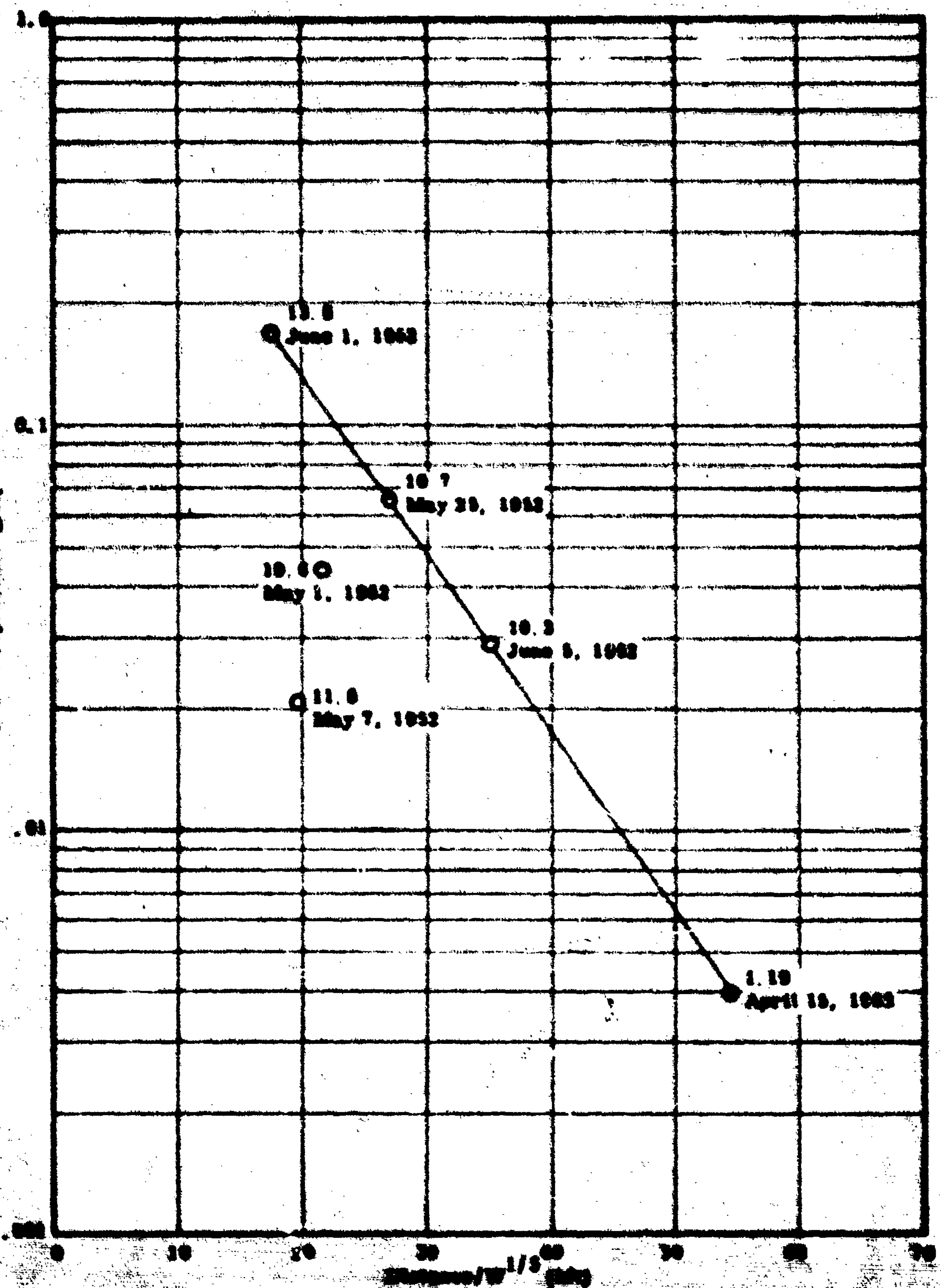

Fig. 1.27 -- Peak overpressure vs distance/$W^{1/3}$

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